INFLUENCE OF FLOAT MATERIALS ON THE QUALITY OF 'd'ANJOU' PEARS AFTER REGULAR AND CONTROLLED ATMOSPHERE STORAGE

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ABSTRACT

Thirty bins of commercially harvested 'd'Anjou' pears from each of three growers were packed at a commercial packing facility, using either of two pear float materials and wrapping the pears in one of three paper wraps. Float materials used were potassium phosphate (XEDA-F, pH 11.3) or lignin sulfonate (lignosite), the industry standard. Paper wraps were impregnated with either Biox-A, 3% oil + copper and ethoxyquin (3% C&E), or 6% oil + copper and ethoxyquin (6%C&E). After packing, 36 boxes were placed in regular atmosphere (RA) storage at 1C. Seventy-two boxes were placed in controlled atmosphere (CA) storage (1.5% O_2 and 1.0% CO_2 at 0C). After 50 days (RA) or 100 and 200 days (CA) storage, fruit was removed and quality evaluated. Float material (Lignosite or XEDA-F) did not influence either objective or subjective quality under either RA storage or up to 200 days CA storage. Type of paper wrap did have a strong influence on pear quality, particularly affecting scald rating and subjective ratings of pear quality. Paper wraps containing Biox A produced pears of reduced quality compared to papers with either 3 or 6% oil with C&E, which were comparable in quality.

INTRODUCTION

Moving fruit through a packing facility has long been accomplished using water to transfer the fruit from one location to another. Additional soluble

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materials (sodium lignin sulfonate, sodium sulfate, sodium silicate, sodium carbonate) are added to the water to increase specific gravity so that the very dense pears will float. Lignin sulfonate (lignosite) has been used for many years as the standard float material in the pear industry. This material is non-corrosive to machinery, has no influence on fruit quality at packing or after storage and may have some fungicidal properties (Willett 1982; Sugar and Spotts 1986). Recently, the commercial lignin sulfonate product used in pear packing facilities has become expensive and difficult to obtain. In addition, some waste treatment plants will not accept lignin sulfonate in waste water. Potassium phosphate (XEDA-F) has been suggested as a possible replacement pear flotation material.

Any new flotation material must not impair fruit quality, must be compatible with packing and storage equipment, and procedures. Kupferman (1998) reported that many of the chemicals used commercially to float pears may stain fruit surfaces. Pear quality after storage can be related to a multitude of factors, including cultivar, fruit maturity, tree vigor, harvest procedures, packing material, storage (delay, time and condition) and a combination of these factors (Allen and Claypool 1948; Chen *et al.* 1981; Chen and Varga 1999; Drake 1994; Drake *et al.* 2001; Hansen 1957; Hansen and Mellenthin 1962, 1979; Kupferman and Spotts 1995; Mellenthin *et al.* 1980; Meheriuk 1988; Richardson and Kupferman 1999). Many fruit quality problems do not become visible until after some time in storage and under various storage conditions. This study was conducted to determine the effects of two commercially available float materials on pear quality as affected by paper wraps and various storage conditions.

MATERIALS AND METHODS

Thirty bins of commercially harvested 'd'Anjou' pears from each of three growers were packed at Blue Star Growers, Cashmere, WA, a commercial packing facility, using either of two pear float materials and wrapping the pears in one of three paper wraps. Fruit had been held at 0C for 45 days in regular atmosphere (RA) before packing. Float materials used were potassium phosphate (XEDA-F, pH 11.3) or lignin sulfonate (lignosite), the industry standard. Specific gravity of both floats was adjusted to 1.025. The antifungal compound sodium ortho-phenylphenate (3,800 ppm) was added to each dump tank mixture. Standard amounts of TBZ, Biosave and wax were applied to the pears before packing. Paper wraps were impregnated with either Biox-A, 3% oil + copper and ethoxyquin (3% C&E), or 6% oil + copper and ethoxyquin (6% C&E). After commercial packing, 108 boxes of fruit (6 boxes of each float material, paper wrap and grower) were selected and stored. Thirty-six boxes were placed in regular atmosphere (RA) storage at 1C. Seventy-two boxes were placed in

controlled atmosphere (CA) storage (1.5% O_2 and 1.0% CO_2 at 0C). After 50 days (RA) or 100 and 200 days (CA) storage, fruit was removed and quality evaluated.

Pear fruit quality was evaluated using 20 pears immediately after removal from storage and on 20 pears after an additional 7 days of ripening at 20C. The remaining pears in each box were evaluated for rot and physiological disorders immediately after removal from storage. Quality factors evaluated were flesh firmness, external and internal color, soluble solids (SS), titratable acidity (TA), general appearance, finish, and visually detectable disorders (scald, shrivel). Firmness was determined using the TA-XT2 Texture Analyzer (Texture Technologies, Scarsdale, NY) equipped with a 7.7 mm probe. External and internal color was determined with the Color Flex (Hunter Assoc., Reston, VA) using the Hunter L*. a*, b* system and calculated hue values (Hunter and Harold 1987). SS and TA were determined from a composite of juice expressed from longitudinal slices from each of 20 fruits. An Abbé type refractometer with a sucrose scale calibrated at 20C was used to determine SS. TA was determined with a Radiometer titrator, model TTT85 (Radiometer, Copenhagen, Denmark). Acids were titrated to pH 8.2 with 0.1N NaOH and expressed as percent malic acid. Subjective color, phytotoxicity, scald, calyx-end browning and decay were evaluated after each storage period by laboratory personnel familiar with pear storage problems using a rating scale of 0 to 4 (0 = excellent and 4 = poor) or (0 = none and 4 = severe). These subjective evaluations were conducted at the same time at two different laboratories (USDA, ARS-TFRL and Washington Tree Fruit Research Commission). After RA (50 days) and CA (200 days), one tray of 20 pears from each paper type and storage condition was evaluated for general appearance, finish, scald, stem condition and physiological disorders by 15 individuals skilled in quality control from four warehouses located in the Wenatchee, WA area, using a scale of 1 = none/excellent, 2 = slight/good, 3 = moderate/fair and 4 = extreme/poor. Pears receiving scores above 2.5 were considered marginally acceptable and those receiving scores 3.0 or greater were considered unacceptable. Data were analyzed as a completely randomized design using growers as replications, pear floats as the whole plot and paper wraps as split plots. Means showing a significant F value were separated using Tukey's HSD test.

RESULTS AND DISCUSSION

Flotation material had no influence on the peel color of the pears, regardless of the length or type (RA or CA) of storage (Table 1). No peel color difference was detectable in pears from the different paper wraps after 50 days of RA or 100 days of CA. However, after 200 days of CA storage, pears

wrapped in paper containing 6% C&E were more yellow (lower hue values) than pears stored in either 3% C&E or Biox A. This difference in hue was more than 1 unit and would be visible to the consumer (Hunter and Harold 1987). In a previous study, no peel color difference was evident between pears wrapped in paper containing 3% oil with C&E or 6% oil with ethoxyquin (Drake *et al.* 2001). Regardless of the type or length of storage, a 7-day ripening period resulted in a distinct color change from green to more yellow (higher L and lower hue values). No interactions were evident among factors for peel color.

TABLE 1.
PEEL COLOR OF 'd'ANJOU' PEARS AS INFLUENCED BY STORAGE TYPE, FLOAT MATERIAL, PAPER WRAP AND RIPENING TIME

	RA, 50 days		CA, 100 days		CA, 200 days	
	L*	Hue	L*	Hue	L*	Hue
Float Materials						
Lignosite	59.5a[z]	99.9a	57.2a	103.4a	59.9a	99.4a
XEDA-F	59.0a	100.5a	57.1a	103.9a	59.3a	99.8a
Paper Wraps						
Biox A	58.7a	100.4a	57.2a	103.6a	59.3a	99.9a
3% C&E	59.8a	100.1a	57.2a	103.8a	59.7a	100.1a
6% C&E	59.4a	100.0a	57.1a	103.4a	59.8a	98.7b
Ripe, days						
0	57.4b	103.4a	56.5b	106.1a	57.8b	103.2a
7	61.1a	96.9b	57.8a	101.2b	61.4a	96.0b
F x PW	ns	ns	ns	ns	ns	ns
F x Ripe	ns	ns	ns	ns	ns	ns
F x PW x Ripe	ns	ns	ns	ns	ns	ns

[z] Means in a column within a factor not followed by a common letter are significantly different ($P \leq 0.05$) by THSDT.

Type of float material or paper wrap had no influence on fruit flesh color regardless of the type or length of storage (Table 2). Allowing pears to ripen for 7 days resulted in lower internal L and hue values, indicating darker and more yellow flesh after ripening. No interactive effects for flesh color were observed among float material, paper type or ripening.

TABLE 2.
FLESH COLOR OF 'd'ANJOU' PEARS AS INFLUENCED BY STORAGE TYPE, FLOAT MATERIAL, PAPER WRAP AND RIPENING TIME

	RA, 50 days		CA, 100 days		CA, 200 days	
	L*	Hue	L*	Hue	L*	Hue
Float Materials						
Lignosite	70.0a[z]	86.3a	76.5a	87.9a	75.2a	87.6a
XEDA-F	70.2a	86.4a	76.6a	88.5a	76.1a	88.0a
Paper Wraps						
Biox A	69.7a	86.5a	76.5b	88.2a	75.3a	87.6a
3% C&E	70.8a	86.3a	76.4b	88.2a	75.4a	87.8a
6% C&E	69.8a	86.3a	76.8a	88.2a	76.2a	87.6a
Ripe, days						
0	72.2a	87.5a	76.7a	88.6a	75.6a	88.5a
7	68.0b	85.2b	76.4b	87.8b	75.7a	87.0b
F x PW	ns	ns	ns	ns	ns	ns
F x Ripe	ns	ns	ns	ns	ns	ns
F x PW x Ripe	ns	ns	ns	ns	ns	ns

[z] Means in a column within a factor not followed by a common letter are significantly different ($P \leq 0.05$) by THSDT.

Pear firmness remained commercially acceptable and was not influenced by either float material or length of storage (Table 3). Under RA conditions only, pears wrapped in paper containing Biox A were firmer than pears wrapped in paper containing 3% C&E. Pears wrapped in paper containing 6% C&E were

transitional in firmness between the two other paper types. This difference in firmness among different paper types was only 2 N and would not be considered economically significant. After 7 days of ripening, pears attained acceptable (<20N) firmness levels regardless of float material and/or paper wrap.

TABLE 3.
FIRMNESS AND SCALD OF 'd'ANJOU' PEARS AS INFLUENCED BY STORAGE TYPE, FLOAT MATERIALS, PAPER WRAPS AND RIPENING TIME

	Firmness (N)			Scald (%)	
	RA, 50 days	CA, 100 days	CA, 200 days	RA, 50 days	CA, 100 days
Float Material					
Lignosite	30.9a[z]	34.3a	32.6a	0.0a	6.3a
XEDA-F	32.0a	34.9a	34.0a	0.0a	4.0a
Paper Wraps					
Biox A	32.4a	34.7a	32.7a	0.0a	12.3a
3% C&E	30.3b	34.1a	33.6a	0.0a	0.4b
6% C&E	31.6ab	35.0a	33.6a	0.0a	2.8b
Ripe, days					
0	53.6a	57.4a	55.1a	0.0a	0.0a
7	9.2b	11.8b	11.5b	0.0a	10.4b
F x PW	ns	ns	ns	ns	ns
F x Ripe	ns	ns	ns	ns	ns
F x PW x Ripe	ns	ns	ns	ns	ns

[z] Means in a column within a factor not followed by a common letter are significantly different ($P \leq 0.05$) by THSDT.

Scald was not detected after RA storage either before or after ripening but was visible after ripening for both CA storage regimes (Table 3). Flotation material had no influence on the amount of scald present after ripening regardless of CA storage term. In contrast, in either CA storage term paper type had a strong influence on the amount of scald present after ripening. Pears wrapped in paper containing Biox A displayed unacceptably high scald ratings.

Subjective evaluation of scald and calyx-end browning by other laboratory personnel (WTFRC) agreed with objective and subjective data obtained by the USDA, ARS, TFRL (Table 4). Float material had no influence on the amount of scald or calyx-end browning present regardless of storage type or time. The amount of scald present was strongly influenced by paper wrap, but only after 200 days of CA storage. Pears in paper wrap containing Biox A displayed significantly more scald than pears in either 3 or 6% C&E. Subjective evaluations of skin color confirmed the objective data showing that float material had no influence on peel color.

TABLE 4.
SUBJECTIVE EVALUATION (WTFRC) OF THE EFFECT OF PEAR FLOATS AND PAPER WRAPS ON 'd'ANJOU' PEAR SCALD AND CALYX-END BROWNING

	Scald Index[z]			Calyx-end Browning[y]		
	RA, 50 days	CA, 100 days	CA, 200 days	RA, 50 days	CA, 100 days	CA, 200 days
Float Material						
Lignosite	1.6a[x]	0.2a	6.7a	0.0a	0.0a	0.0a
XEDA-F	1.4a	0.8a	5.3a	0.0a	0.0a	0.0a
Paper Wraps						
Biox A	2.1a	0.8a	14.3a	0.0b	0.0b	0.0a
3% C&E	1.2a	0.2a	0.1b	0.0b	0.0b	0.0a
6% C&E	1.3a	0.5a	3.6a	0.1a	0.1a	0.0a

[z] Scald index is the mean rating (0 to 4) × 100.
[y] Proportional date were transformed to arcsine square-root values before analysis of variance.
[x] Means in a column within a factor not followed by a common letter are significantly different ($P \leq 0.05$) by THSDT.

Subjective scores for finish, scuffing, scald and stem condition were similar for pears after 50 days of RA storage and analogous for scald and stem condition after 200 days of CA storage regardless of the type of float material used (Table 5). After 200 days of CA storage, scores for finish and scuffing were not as acceptable for pears from the Lignosite float material as compared to the XEDA-F float material. This difference in the marginal scores for finish (0.5) and scuffing (0.3) for pears in the Lignosite float was consistent across all 15 evaluators.

Scores for finish, scuffing, scald and stem condition were strongly influenced by the type of paper wrap used with the pears (Table 5). Pears in paper with Biox A were graded unacceptable (2.5+) for finish after only 50 days in RA storage and marginal after 200 days in CA. After CA storage, finish scores were comparable between pears in paper with Biox A and 6% C&E. Pears in paper with 3% C&E received the best score for finish after CA storage. Scores for scuffing were similar between pears regardless of paper type after RA storage. After CA storage, pears in paper with Biox A were not as acceptable as pears in paper with either 3 or 6% C&E. Scores for scald were best for pears in paper containing 3 or 6% C&E compared to pears in paper with Biox A. Subjective stem condition scores were comparable between pears in paper with either Biox A or 3% C&E after 50 days of RA storage Stem condition scores were unacceptable (>2.5) for pears in paper with 6% C&E after RA storage. After CA storage, pears in paper with Biox A were scored not as acceptable as pears in paper with either 3 or 6% C&E.

TABLE 5.
SUBJECTIVE EVALUATION OF COMMERCIALLY PACKED 'd'ANJOU' PEARS USING TWO FLOAT MATERIALS AND THREE PAPER WRAPS AFTER 50 DAYS OF REGULAR ATMOSPHERE (RA) OR 200 DAYS OF CONTROLLED ATMOSPHERE (CA) STORAGE

	Finish[z]		Scuffing[z]		Scald[z]	
	RA	CA	RA	CA	RA	CA
Float Materials						
Lignosite	2.0a[y]	2.4a	1.8a	1.8a	1.3a	1.6a
XEDA-F	2.2a	1.9b	1.9a	1.5b	1.1a	1.5a
Paper Wraps						
Biox A	2.7a	2.4a	2.1a	1.9a	1.4a	2.3a
3% C&E	1.8b	1.7b	1.7a	1.6b	1.1b	1.0b
6% C&E	2.1b	2.3a	1.8a	1.4b	1.1b	1.4b
F x PW	ns	ns	ns	ns	ns	ns

[z] Evaluated on a scale of (1 to 4), 1 = none; 2 = slight; 3 = moderate; 4 = severe or 1 = excellent; 2 = good; 3 = fair; 4 = poor (N = 15)

[y] Means in a column within float materials or paper wraps not followed by a common letter are significantly different by THSDT ($P \leq 0.05$).

CONCLUSIONS

Float material (Lignosite or XEDA-F) did not influence either objective or subjective quality under either RA storage or up to 200 days CA storage. Type of paper wrap did have a strong influence on pear quality, particularly affecting scald rating and subjective ratings of pear quality. Paper wraps containing Biox A produced pears of reduced quality compared to papers with either 3 or 6% oil with C&E, which produced pears that were comparable in quality.

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REFERENCES

ALLEN, F.W. and CLAYPOOL, L.L. 1948. Modified atmosphere in relation to the storage life of Bartlett pears. Proc. Amer. Soc. Hort. Sci. *59*, 192–204.

CHEN, P.M., SPOTTS, R.A. and MELLENTHIN, W.M. 1981. Stem-end decay and quality of low oxygen stored 'd'Anjou' pears. J. Amer. Soc. Hort. Sci. *106*, 522–527.

CHEN, P.M. and VARGA, D.M. 1999. Controlled atmosphere storage of pears. In *Proc. 7th. Intl. Controlled Atmosphere Res. Conf.* Vol. 2, pp. 85–90, Davis, CA.

DRAKE, S.R. 1994. Elevated carbon dioxide storage of 'Anjou' pears using purge-controlled atmosphere. Hort. Sci. *29*, 299–301.

DRAKE, S.R., ELFVING, D.C. and GIX, R.D. 2001. The influence of paper wraps on the quality of 'd'Anjou' pears after controlled atmosphere storage. Hort. Tech. *25*, 155–164.

HANSEN, E. 1957. Reactions of Anjou pears to carbon dioxide and oxygen content of the storage atmosphere. Proc. Amer. Soc. Hort. Sci. *52*, 192–204.

HANSEN, E. and MELLENTHIN, W.M. 1962. Factors influencing susceptibility of pears to carbon dioxide injury. Proc. Amer. Soc. Hort. Sci. *80*, 146–153.

HANSEN, E. and MELLENTHIN, W.M. 1979. Commercial handling and storage practices for winter pears. Ore. State Univ. Agr. Expt. Sta. Rpt. 550.

HUNTER, R.S. and HAROLD, R.W. 1987. *The Measurement of Appearance*, 2nd Ed., pp. 411, Wiley, New York.

KUPFERMAN, E. 1998. Postharvest applied chemicals to pears: A survey of pear packers in Washington, Oregon and California. Tree Fruit Postharvest J. *9*, 3-24.

KUPFERMAN, E. and SPOTTS, R. 1995. Practices to reduce postharvest pear diseases. Tree Fruit Postharvest J. *6*, 18-23.

MEHERIUK, M. 1988. Harvest maturity and storage regime for pears. Washington State Univ. Coop. Ext. Postharvest Pom. Nwsl., 6-15.

MELLENTHIN, W.M., CHEN, P.M. and KELLY, S.B. 1980. Low oxygen effects on dessert quality, scald prevention and nitrogen metabolism of 'd'Anjou' pear fruit during long term storage. J. Amer. Soc. Hort. Sci. *105*, 695-698.

RICHARDSON, D.G. and KUPFERMAN, E. 1999. Controlled atmosphere storage of pears. In *Proc. 7th Intl. Controlled Atmosphere Res. Conf., Vol. 2*, pp. 31-35, Davis, CA.

SUGAR, D. and SPOTTS, R.A. 1986. Effects of flotation salt solutions on spore germination of four decay fungi and on side rot of pear. Plant Dis. *70*, 110-112.

WILLETT, M. 1982. Unpublished data. Cooperative Extension Service, Oregon State University, Medford, OR.